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Watershed Program Evaluation

PLUM CREEK, KENTUCKY

interim progress report

ARS 43-85

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

JANUARY 1959

Prepared in

Farm Economics Research Division

Agricultural Research Service

United States Department of Agriculture

PREFACE

This interim report describes progress achieved to July 1, 1957, toward carrying out an appraisal of the benefits and costs of the flood prevention measures installed in the Plum Creek Pilot Watershed, Ky. The survey is a joint undertaking of the Farm Economics Research Division, Agricultural Research Service, and the Soil Conservation Service. It was initiated under provisions of the "Memorandum of Agreement between the Soil Conservation Service and the Agricultural Research Service relating to Services to be furnished by the ARS under the Watershed Protection Appropriation Item," March 10, 1955.

A plan of evaluation developed by the Soil Conservation Service in 1954 was included in the Work Plan for Plum Creek Watershed, 1954. Representatives of the Soil Conservation Service who made a functional inspection of the program evaluation on June 21 and 22, 1955, suggested that the economic phases of the evaluation be intensified. The group recommended that the Agricultural Research Service develop with the Soil Conservation Service a proposal to supplement and amend methods and procedures for the economic evaluations. Accordingly, an outline of study aimed at intensifying the evaluation of the program was prepared and approved by the Soil Conservation Service in October 1955.

The evaluation procedure set forth in the outline was developed in consultation with Herschel Hecker, State Conservationist, Erwin C. Ford, Watershed Planning Branch, Soil Conservation Service, and J. E. McLean, Engineering and Watershed Planning Unit, Spartanburg, S. C. William Bennett, Agricultural Economist, Farm Economics Research Division, ARS, stationed at Shelbyville, Ky., collected the field data and compiled and analyzed the statistics. He was assisted by Frank Rohrer and John Carr, Work Unit Conservationists and members of the State Conservationist's Staff.

This progress report is concerned primarily with those phases of the evaluation assigned to the Farm Economics Research Division, ARS. Accomplishments in other evaluation activities performed by the Soil Conservation Service are included to a limited extent in order to provide a framework for the economic report. Considerable data contained herein were obtained from physical scientists of the Soil Conservation Service, study of the Watershed Work Plan, and the watershed project files.

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WATERSHED PROGRAM EVALUATION
PLUM CREEK, KENTUCKY

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SUMMARY

The watershed-protection program for Plum Creek Watershed is nearing completion. In terms of cost, about 80 percent of the land-treatment measures have been installed. Nine of the 12 floodwater-retarding structures needed have been constructed.

This interim report sets forth the plan of evaluation in operation, accomplishments under the plan, and some preliminary estimates of project effects. Progress in evaluation of effects of the watershed program has been limited thus far primarily to collection and analysis of basic watershed data.

To achieve evaluation objectives, gages and other devices for measuring precipitation, runoff, and sediment were installed. Economic surveys of land use, production, management, and conservation were made in sample study areas and in the flood plain. Continuing surveys to observe changes in these factors brought about by the watershed-protection program are underway. Costs of works of improvement have been assembled and summarized.

More than 98 percent of the watershed land is in farms. Approximately 140 farms averaging 168 acres in size are wholly or partly within the watershed. Major farm enterprises are dairy, other livestock, and tobacco. In 1955, gross sales per farm averaged $6,860 and income from off-farm employment was substantial on about 18 percent of the farms. Major uses of farmland in 1955 were cropland 31 percent, pasture, 63 percent, and other uses, 6 percent. In sample upland study areas, tobacco and corn made up 25 percent of all cropland. On the flood plain, these crops made up 64 percent of all cropland.

A greater than proportionate share of the most intensive crops in the watershed are grown on the flood plain. Although flood-plain lands represent 4.2 percent of the total watershed area, approximately 19 percent of the tobacco and 17 percent of the corn are grown on these lands. The value of production from these two crops represents about 90 percent of the value of all crop and pasture production obtained in the flood plain.

Use of flood-plain lands in 1955 included 46 acres idle, 41 acres wooded, and 114 acres of permanent pasture. Records to date reveal no significant intensification of use because of flood protection. Intensified use of flood-plain lands is not expected until a few years after flood-protection measures are installed.

In the flood plain, fixed improvements partly protected from floods by flood-prevention measures installed include 15 houses, 1 store building, 5 barns, 14,520 feet of public roads, 6 highway bridges, and 6,270 rods of fence.

Economic surveys of land use in sample upland areas indicate that the total acreage of land in crops and permanent pasture has not changed significantly. However, a net reduction of 8 percent in crops raised on steep and eroded land (class VI) was observed. In the sample study areas, use and management in 1956 on about 60 percent of the fields were meeting minimum or greater conservation requirements. On the remaining fields, changes in use or additional conservation practices were needed.

Other tentative appraisals of program effects are concerned with costs of conservation measures, on-site benefits of selected conservation measures, and water management in reservoir areas.

Average costs for establishing conservation measures have been $67.58 per acre for revegetation of critically eroding areas, $24.47 per 100 linear feet of subwatershed waterway improvement, $8.02 per acre of cover cropping, $8.45 per acre of pasture seeding, and $1.63 per acre of pasture mowing.

During the first year after seeding critically eroding areas, returns from grazing increased $10 per acre. Plantings of this kind were established on 283 acres in 1955 and 1956.

From the start of the watershed program to July 1957, water-storage facilities increased from 130 to 580 acre-feet. About 80 percent of the 450 acre-foot increase was provided by the sediment pools of floodwater-retarding structures and the rest by farm ponds. The additional stored water has been used largely for livestock. Although irrigation is not practiced in the watershed, two farmers said they intended to use the storage facilities as sources of water for irrigating tobacco.

All of the ponds above floodwater-retarding structures have been stocked with fish. Three of the ponds were fished in 1957 and the remaining six are expected to come into production in 1958. During the summer of 1957, approximately 250 fishing visits were made in one pool, from which 500 pounds of fish were taken.

The flood of April 4, 1957, the only one that occurred since the inception of the project, inundated about 20 percent of the flood plain. No land was inundated on the flood plains of those tributaries on which floodwater-retarding structures were located. In addition to 15 acres of land damaged by scouring, damages to fixed improvements and crops totaled about $1,370. If no flood-prevention measures had been in operation at the time of the 1957 flood, losses would have been greater. The amount of this benefit will be evaluated during the project evaluation.

THE BACKGROUND

The Plum Creek Watershed Protection Project is one of the 65 watersheds selected for the pilot program established by the Agricultural Appropriations Act, 83rd Congress, 1st Session. In view of the legislative history of this program, the Department of Agriculture regards the intent of the Congress to be that evaluation studies are to be made on pilot watersheds to determine the benefits to be derived from the recommended programs. Broad objectives of these evaluation studies, as set forth by the Soil Conservation Service, are to estimate the effects of the program on:

1. Reducing erosion and sedimentation and the resultant benefits to farm owners and operators and other interests.

2. Runoff and the resultant benefits to farm owners and operators and other interests.

3. The economy of the area.

In keeping with resources available for evaluation, intensive surveys were limited to 10 projects, and more general investigations were planned for the remaining watershed projects. The 10 projects in which intensive surveys are underway include Plum Creek, Ky.; Salem Fork, W. Va.; North Fork of the Broad River, Ga.; Upper Salt Creek, Nebr.; Pleasant Creek, Utah; Kiowa Creek, Colo.; Six Mile Creek, Ark.; Honey and Mule Creeks, Iowa; and East Willow Creek, Minn.

Plum Creek, a tributary of Salt River, is approximately 17 miles long; it drains a watershed of 23,688 acres situated in Shelby, Spencer, Jefferson, and Bullitt Counties. The watershed consists of approximately 160 farms and a small village and has a population of about 700 people. A work plan was developed for the project in 1954 and installation of works of improvement under authority of the pilot watershed program was commenced in the same year.

THE PROGRAM FOR WATERSHED PROTECTION

Estimated watershed requirements of conservation measures that contributed directly to flood prevention were set forth in the Work Plan for Plum Creek Watershed, August 1954. These recommended improvements were developed by first estimating the land-treatment practices and measures needed to provide a practical reduction of soil erosion and runoff retardation. Included in this group of measures are contour farming, cover cropping, diversions, pasture seeding, ponds, terraces, waterway development, fencing of woodlands, and pasture improvement.

Other flood-prevention measures were considered after the reduction in flood and sediment damages expected to accrue from land treatment was computed. Measures in this group include floodwater-retarding structures, stream-channel improvement, subwatershed waterway improvement, roadside stabilization, tree planting, and revegetation of critical areas. The

quantity of the measures recommended was based on an economic evaluation of costs and benefits of each measure considered. No separable functioning measure or group of measures functioning as a whole were included unless the benefits exceeded the costs.

The recommended works of improvement contemplated in the work plan as scheduled for installation over a 5-year period are shown in table 1. The quantities of recommended measures revised at a later date when more detailed farm plans had been prepared are included also in table 1. Installation of the land-treatment measures is facilitated by technical assistance and cost-share payments of going programs, along with accelerated technical assistance provided by the watershed program.

Table 1.- Improvements required for flood protection, Plum Creek Watershed, Ky. 1/

Works of improvement	Unit	Applied before July 1, 1953	Recommended in work plan	
			July 1, 1953 2/	Revised December 1956
Floodwater-retarding structures	Number	---	13	12
Stream-channel improvement	Mile	---	21	21
Subwatershed waterway improvement	do.	---	95	95
Roadside stabilization	do.	---	12	12
Woodland planting	Acre	---	235	139
Revegetation of critical areas	do.	---	450	450
Contour farming	do.	1,375	5,170	2,281
Cover cropping	do.	1,989	6,130	2,829
Diversion construction	Mile	1.7	8	7.7
Terracing	do.	13	78	7.3
Waterway development	Acre	38	220	106
Ponds	Number	129	320	105
Pasture seeding	Acre	1,020	2,940	6,128
Pasture improvement	do.	1,805	5,880	9,040
Fencing woodland	do.	10	750	93
Land use conversions:				
Cropland to pasture or woodland	do.	3/	1,519	1,519
Pasture to woodland	do.	3/	255	255
Pasture to cropland	do.	3/	3,685	3,685
Idle land to cropland	do.	3/	157	157

1/ From Work Plan for Plum Creek Watershed, August 1954.

2/ The watershed project was commenced during the fiscal year beginning July 1, 1953. Quantities of recommended improvements listed in the work plan exclude those installed before July 1, 1953.

3/ Not determined.

When the work plan was prepared, it was estimated that the proposed land-treatment measures and practices would reduce average annual flood losses by 20 percent. Structural improvements would reduce these losses by an additional 57 percent. Average annual flood damages were computed on the basis of floods experienced from 1938 to 1952, inclusive. The reduction in frequency of flooding was estimated to increase annual net income by nearly $16,000 on some flood-plain lands by making intensification of land use economically feasible. Work-plan estimates of average annual damages to crops, land, and fixed improvements situated on bottom lands adjacent to the main stem of Plum Creek and its tributaries are as follows:

Damage	Dollars
Crops and pasture	15,930
Scour and deposition of farmland	5,790
Fences, ditches, farm roads, buildings	19,180
Public roads and bridges	940
Total	41,840

The recommended watershed measures were also expected to provide annual conservation benefits of $153,000.

In consideration of the revised quantities of works of improvement recommended December 1956, current estimates of benefits are lower than those cited above. As the revised needs are concerned almost entirely with land treatment measures, the reduction in expected conservation benefits is substantial, but the reduction of flood-prevention benefits is only minor.

The 12 floodwater-retarding structures recommended would be located throughout the watershed to provide temporary storage of runoff from approximately 31 percent of the total watershed. These structures, which consist of earth embankments, outlet conduits, and grassed emergency spillways, are designed so that the available temporary storage will regulate the runoff (average 2.5 inches) from the design storm to nondamaging proportions immediately below the dams and lesser amounts at points downstream. The emergency spillways will furnish adequate protection to the structures from storms that will produce greater runoff than the design storm.

For the 12 planned structures as a whole, the total storage capacity would be 2,391 acre-feet--297 acre-feet in the sediment pools and 2,094 acre-feet in detention pools. The total surface area of the sediment pools would equal 66 acres, while the corresponding area (including area of the sediment pools) at the top of the detention pools would be 248 acres. Maximum dam heights of the 13 structures would average about 30 feet, and the total volume of fill required for their construction would be 305,846 cubic yards.

The effect of the floodwater-retarding structures on stream discharge at downstream points on Plum Creek and its tributaries will depend upon the meteorologic and hydrologic characteristics of the storm-producing flood. Measurements of these factors for future storms will be made. Thus the effects of a structure or group of structures will be estimated.

Improvement of 21 miles of Plum Creek channel by removing drifts, sand bars, undergrowth and overhanging trees, and by intermittent straightening, widening, and deepening will increase discharge capacity, lower flood stages, and thereby decrease flood losses. Enlargement of channel capacity will supplement the effectiveness of other flood-prevention measures and will provide a major role in reducing flood flows produced by runoff from adjacent areas.

Other flood-prevention measures to be installed for management of concentrated runoff are subwatershed waterway improvement, diversions, and small on-farm waterway development. Straightening, sloping, shaping, and seeding of small subwatershed waterways is required to prevent erosion and meandering and to provide stable channels for conveying runoff to the larger streams. The construction of diversions is required to protect low-lying fields from damage caused by adjacent hillside runoff. Most of these diversions will be installed on the margins of flood-plain fields. Farm waterway developments smaller than those described will provide grassed channels to carry runoff collected by terraces and stabilized watercourses, thereby reducing erosion and sedimentation. Construction of waterway developments of this kind in many rotation crop fields will be accomplished by leaving designated areas in grass when plowing.

Other measures shown in table 1 are needed to prevent erosion and retard runoff largely by improving vegetative growth, and by cross-slope farming. Farm ponds will be constructed to provide stockwater on those lands being converted to pasture and to permit controlled grazing on existing pastures by furnishing adequate distribution of stockwater supplies. The resulting improved cover conditions of pastureland will aid in erosion control and runoff retardation.

The recommended land use adjustments indicated in table 1 are necessary to establish uses in accordance with limitations of the lands in respect to conservation requirements and for improved watershed protection.

The total cost of program installation was estimated to be $1,014,753. This included $451,137 for structural measures, including revegetation of critical areas, and $563,616 for land-treatment measures. About $21,150 of the cost for land treatment was expected to be borne by the Agricultural Conservation Program Service.

PROGRESS TOWARD COMPLETION OF PROGRAM

In terms of cost, the recommended watershed program is approximately 70 percent completed. The quantity and total cost of the various measures recommended and of those installed as of June 30, 1957, are shown in table 2.

Structural Measures

Although the general plan of structural improvements was completed at the time approval for project installation was granted, it was necessary to design detailed plans or specific structures for contract purposes and

Table 2. - Progress in installing works of improvement, Plum Creek Watershed, Ky., June 30, 1957

Works of improvement	Unit	Estimated needs 1/		Completed 2/	
		Quantity	Cost	Quantity	Cost 3/
			Dollars		Dollars
Structural measures:					
Floodwater-retarding structures	Number	12	335,144	9	246,776
Stream-channel improvement	Mile	21	37,504	0	0
Subwatershed-waterway improvement	do.	95	41,411	8.1	8,827
Roadside stabilization	do.	12	1,800	0	0
Woodland planting	Acre	139	6,478	37	2,109
Revegetation of critical areas	do.	450	28,800	283	19,125
Total	-----	---	451,137	---	276,837
Land-treatment measures:					
Contour farming	Acre	2,281	572	2,071	520
Cover cropping	do.	2,829	18,021	2,302	14,664
Diversion construction	Mile	7.7	1,836	3.6	760
Terracing	do.	7.3	379	1.8	93
Waterway development	Acre	106	10,600	60	6,000
Ponds	Number	105	15,750	88	13,200
Pasture seeding	Acre	6,128	306,400	4,536	226,800
Pasture improvement	do.	9,040	180,800	7,721	154,400
Fencing woodland	do.	93	2,418	13	338
Land use conversions 4/:					
Cropland to pasture or woodland	do.	1,519	---	1,000	---
Pasture to woodland	do.	255	---	37	---
Pasture to cropland	do.	3,685	---	2,200	---
Idle land to cropland	do.	157	---	95	---
Farm planning and application	do.	21,671	22,000	18,590	18,962
Forest management assistance	do.	3,235	4,840	17	26
Total	-----	---	563,616	---	435,763
Grand total	-----	---	1,014,753	---	712,600

1/ Estimated needs at start of program July 1, 1953, revised December 1956.

2/ From semi-annual reports of conservation accomplishments from July 1, 1953, to June 30, 1957, inclusive.

3/ Costs of land-treatment measures completed were estimated by applying the same costs per unit of measure as were used in computing the costs of "estimated needs."

4/ When land use conversions require outlays for land clearing, seeding, fencing, or other improvements, such costs are included with costs of other measures.

construction. Attainment of easements and rights-of-way posed difficulties in some instances. However, through negotiations and minor changes in sites, the way to construction was cleared for 12 floodwater-retarding structures.

Contract was made June 2, 1954, for construction of floodwater-retarding structure No. 4, the first one built. Structures Nos. 1, 2, 11, and 12 were built in 1955 and Nos. 3, 15, 17, and 18 in 1956. Structure No. 7, the tenth one, was started in 1957 but not completed by June 30. Costs of the installed structures borne by Federal, other public, and private interests are shown in table 3. Federal costs, which were almost exclusively for engineering services and construction, amounted to 90 percent of the total. Farmers who owned land adjacent to the structures furnished land and rights-of-way equivalent in value to 10 percent of the total cost. To date, no appurtenant facilities have been constructed by farmers who operate lands bordering on the reservoirs.

The actual cost of installing floodwater-retarding structures as shown in table 4 was 31 percent higher than estimated costs indicated in the work plan. A major part of this increase was due to rising construction costs and to the larger volume of fill required for construction than had been estimated.

Design features of the floodwater-retarding structures as planned and constructed are indicated in table 5. The combined drainage area of the installed structures is 94 percent of the original estimate; storage capacities of sediment and detention pools are 143 and 100 percent of original estimates, respectively; while the total volume of fill is 118 percent of the original estimate.

About 8.5 percent of the recommended subwatershed waterway improvement has been completed. No particular problems were encountered in their installation. Easements were not necessary. Straightening, sloping, shaping, and seeding waterways were accomplished through contracts with local firms. Lengths of the waterways improved in this way ranged from 400 to 4,795 feet on individual farms. Owing to favorable weather, good stands of Ky. 31 fescue have become established in all improved channels.

Of the total cost of improving subwatershed waterways, the Federal Government paid 92 percent, and the farmers supplied the balance. The total cost per 100 feet of waterway completed averaged $20.62 in contrast to the $8.26 per 100 feet estimated cost in the work plan. Because of the relatively small quantity of this measure installed, the difference in cost per unit is not significant.

As of June 30, 1957, stream-channel improvement on the main stem of Plum Creek had not reached the installation stage. Channel profiles and cross-sections have been made preparatory to designing the needed construction. The economic feasibility of the improvement was reexamined and found to be favorable. Easements and rights-of-way appear to be forthcoming whenever construction is begun. Construction will be started as soon as maintenance of the improved channel is assured by a local organization.

Establishment of vegetation on critically eroding areas has progressed according to plan. Revegetation has been accomplished on about 63 percent of the acreage recommended for treatment by this practice. The Federal Government bore 74 percent of the total cost, while farmers contributed the rest through land clearing, grubbing, and grass seed. The average cost per acre of $67.58 is only 5.5 percent more than the cost estimated in the work plan.

Table 3. - Cost of installed works of improvement as of June 30, 1957, Plum Creek Watershed, Ky.

Works of improvement	Cost			
	Federal	Other public	Private	Total
	Dollars	Dollars	Dollars	Dollars
Floodwater-retarding structures:				
1	20,947	58	3,130	24,135
2	12,316	25	2,033	14,374
3	22,972	40	2,711	25,723
4	28,353	75	4,755	33,183
11	25,267	65	3,905	29,237
12	17,589	22	1,355	18,966
15	30,795	43	2,399	33,237
17	29,353	24	1,184	30,561
18	35,177	32	2,151	37,360
Total	222,769	384	23,623	246,776
Subwatershed-waterway improvement	8,134	---	693	8,827
Revegetation of critical areas	14,100	---	5,025	19,125
Woodland planting	1,332	666	111	2,109
Total	23,566	666	5,829	30,061
All land treatment:				
Installation	43,227	806	372,742	416,775
Farm planning and application	18,988	---	---	18,988
Total	62,215	806	372,742	435,763
Grand total	308,550	1,856	402,194	712,600

From SCS watershed project records and Plum Creek Watershed Work Plan, August 1954.

Table 4. - Estimated and actual cost of installing floodwater-retarding structures, Plum Creek Watershed, Ky.

Structure	Estimated cost 1/				Actual cost 2/			
	Easements and rights-of-way	Engineering assistance	Construction	Total	Easements and rights-of-way	Engineering assistance	Construction	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1	2,980	2,658	14,615	20,253	3,130	3,735	17,270	24,135
2	1,645	2,411	13,260	17,316	2,033	2,317	10,024	14,374
3	3,281	2,628	14,452	20,361	2,711	3,436	19,576	25,723
4	4,411	3,816	20,987	29,214	4,755	3,487	24,941	33,183
11	3,679	2,846	15,651	22,176	3,905	3,757	21,575	29,237
12	1,302	2,494	13,717	17,513	1,355	2,552	15,059	18,966
15	1,969	2,760	15,175	19,904	2,399	5,308	25,530	33,237
17	710	2,992	16,452	20,154	1,184	4,738	24,639	30,561
18	1,700	3,222	17,725	22,647	2,151	6,191	29,018	37,360
Total	21,677	25,827	142,034	189,538	23,623	35,521	187,632	246,776

1/ From Watershed Work Plan, August 1954.
2/ From watershed project records.

Table 5. - Planned and actual construction design features of floodwater-retarding structures, Plum Creek Watershed, Ky.

Structure	Work plan design					Actual construction design				
	Drainage area	Sediment pool	Detention pool	Surface area top of detention pool	Volume of fill	Drainage area	Sediment pool	Detention pool	Surface area top of detention pool	Volume of fill
	Acres	Acre-feet	Acre-feet	Acres	1,000 cubic yards	Acres	Acre-feet	Acre-feet	Acres	1,000 cubic yards
1	554	42.6	173.5	27.5	22.1	554	42	173	27.0	21.4
2	318	17.7	90.0	15.1	20.0	318	32	90	15.0	17.7
3	873	25.9	256.0	30.5	22.5	525	47	256	23.7	29.9
4	1,006	58.2	280.0	41.0	33.3	1,008	80	280	41.0	37.5
11	733	57.2	217.0	34.2	24.0	733	57	217	34.0	32.0
12	227	16.2	72.0	12.1	21.0	270	23	72	11.5	19.7
15	625	15.0	180.0	18.3	24.0	625	15	180	20.5	27.3
17	356	6.3	110.0	6.6	27.0	356	29	110	9.5	30.8
18	657	13.6	198.0	15.8	30.0	657	37	198	17.9	48.0
Total	5,349	252.7	1,576.5	201.1	223.9	5,046	362	1,576	200.1	264.3

From Plum Creek Watershed Work Plan, August 1954, and SCS watershed project records.

Other recommended structural measures listed in the work plan include stabilization of critical roadsides and woodland planting. Roadside work has not yet been started, but discussions of the problem have been held with the sponsoring Soil Conservation Districts and with the County Highway Departments. Current estimates of cost and cost-sharing for this measure are shown in tables 2 and 3. About 37 acres of critically eroding land have been planted to trees. The areas planted consist of small irregularly shaped fields situated on 8 farms. The average cost of establishment was $58.00 per acre.

Land-Treatment Measures

Progress in installing land-treatment measures shown in tables 2 and 6 indicates a high level of accomplishment. In the watershed as a whole, more than 80 percent of the estimated needs of contour farming, cover cropping, ponds, and pasture improvement for watershed protection has been installed. Approximately 4,500 acres of pasture were seeded, of which about 1,000 acres constituted a change from cropland. The remaining acreage seeded was existing pasture with poor cover. In contrast, about 2,200 acres of pastureland were converted to cropping, making a net gain of approximately 1,200 acres of cropland.

In general, farmer acceptance of recommended land treatments is higher on the higher income farms. Although this trend is not consistent so far as all conservation needs are concerned, it is indicated in table 6.

The estimated cost of land-treatment measures installed as of June 30, 1957, is $435,763. The Federal contribution totaled $62,215, of which $18,988 was used to provide technical assistance and the remainder was applied toward the cost of establishing the measures. About 84 percent of the cost of technical assistance was furnished from watershed funds and the balance was supplied by going programs. All of the Federal funds for installation of land treatment, other than those for technical assistance, were provided by going programs.

Private costs of land-treatment measures installed totaled $372,742. Average costs of specific measures estimated at the time the work plan was prepared were applied to the quantities of measures installed to determine the total cost. Appraisals of costs include allowances for all farm labor, equipment, and materials. Surveys to determine actual labor, equipment, materials, and cash costs used in establishing different practices or measures are underway.

LOCAL CONTRIBUTION AND PARTICIPATION

The plan of work for protection of Plum Creek Watershed was prepared by the Soil Conservation Service for the Soil Conservation Districts of Spencer, Shelby, Jefferson, and Bullitt Counties. The District Supervisors reviewed the plan and integrated the parts that affected each district into their respective work plans.

Table 6. - Progress in installation of land-treatment measures on farms classified according to income, Plum Creek Watershed, Ky., July 1, 1957

Item	Gross farm sales in 1955					
	Under $2,001	$2,001 to $4,000	$4,001 to $6,000	$6,001 to $8,000	$8,001 to $12,000	$12,001 and over
	Number	Number	Number	Number	Number	Number
Farms in class	26	28	14	24	26	22
	Percent	Percent	Percent	Percent	Percent	Percent
Percentage of all farms in class	18.6	20.0	10.0	17.1	18.6	15.7
Percentage of all farmland	7.6	15.0	7.8	20.9	21.6	27.1
Percentage of recommended land-treatment measures installed:						
Contour farming	100	77	61	83	81	94
Diversions	0	5	50	42	47	84
Pasture seeding	54	52	64	74	65	68
Pond construction	46	23	0	40	53	87
Terracing	0	0	6	0	0	0
Waterway development	100	28	93	73	76	100
Fencing out woodland	0	0	2	0	0	12
Cover cropping	90	70	93	80	94	100

Gross sales obtained by survey of all farms. Progress in installation of land-treatment measures summarized from semi-annual reports of accomplishment from July 1, 1953, to June 30, 1957.

Since the watershed program began, 150 farmers have requested farm plans and signed agreements to adopt and maintain minimum basic conservation measures. Three additional farmers have applied one or more measures that constitute parts of the minimum conservation requirements.

Easements and rights-of-way were granted by 22 farmers for construction of 9 floodwater-retarding structures and 24 farmers gave easements for improvement of 8 miles of the Plum Creek channel. Total easements and rights-of-way involved 172 acres of land and have an estimated value of $18,500. The former average annual value of cropland and pasture production on lands permanently inundated by reservoirs of 9 installed floodwater-retarding structures amounts to $3,944.

Provisions of the Watershed Protection Easements granted by landowners to Soil Conservation Districts included the following agreements:

1. The District shall have the right, privilege, and authority to use the land described in the indenture for the installation and operation, maintenance and inspection of the described watershed-protection works and measures, and for the storage of waters that may be impounded by the dam or reservoir structure.

2. The District shall be responsible for operating, maintaining, and keeping in good repair the works of improvement.

3. The landowner reserves the right to use the land or any part thereof at any time and for any purpose, provided such use does not interfere with the full enjoyment by the District of the easement conveyed.

4. The easement shall include the right of ingress and egress at any time over and upon said land and any adjoining land owned by the landowner.

5. The landowner releases the District from any and all claims for damages arising from or in connection with the installation or operation and maintenance of the watershed-protection works and measures.

The Soil Conservation Districts were instrumental in obtaining necessary easements and rights-of-way. The time spent by district supervisors in securing easements may be appraised at $100. Costs of recording easements, which were paid by the local districts, averaged $3.25 per transaction and totaled $177. Watershed farmers also contributed about $250 of their time in securing easements.

Local businessmen contributed about $350 to acquire permanent road signs to indicate the perimeter of the watershed protection project.

The Kentucky Division of Flood Control and Water Usage has reviewed plans for and approved the construction of all floodwater-retarding structures.

The Kentucky Department of Fish and Wildlife has stocked all of the sediment pools of floodwater-retarding structures with fish at an estimated cost of $384.

A summary of the local contributions for which a reasonable estimate of value can be made indicates that the total cost of such services exclusive of construction cost is $19,761.

PURPOSE AND PLAN OF EVALUATION

To evaluate the Plum Creek Watershed Project, the Soil Conservation Service has arranged for assistance from the U. S. Geologic Survey and the Farm Economics Research Division, Agricultural Research Service. The Division of Flood Control and Water Usage, Kentucky Department of Conservation, is contributing $2,050 annually toward the program evaluation. Farmers of the watershed are contributing their time to furnish technicians with pertinent information.

Evaluation Objectives and Limitations

Within the framework of the broad objectives of the evaluation stated in the introduction to this report, the plan of study is aimed at appraising during the period of analysis the costs and benefits of the watershed-protection measures in both physical and economic terms. To make this evaluation, it is necessary to measure various physical and economic factors within the watershed and the changes brought about in them by application of the program. This includes appraisal of changes in runoff, flood and sediment damages, and crop and forage production from soil and water conservation improvements. When project benefits are observed and appraised, they are credited, so far as possible, to the measure or group of measures responsible for their accrual.

As presently planned, the evaluation study will be continued through the fiscal year 1961. If funds are available after 1961 and if further results of evaluation appear to be useful, the studies should be continued. Studies during a relatively short period are not likely to provide sufficient observations to permit adequate determination of the long-run average annual benefits and costs. Benefits through reduction of flood damages that accrue during the evaluation period will be limited by the number and magnitude of floods and the rate of installing project measures. Other benefits, such as more intensive use of flood plain, may not materialize for several years after the remedial measures are installed. Thus the short-term aim will be periodically to observe and appraise the effects of installed improvements as they are expressed during the study period. If desired, these short-term appraisals may be used as a basis for verification of long-term estimates of the work plan. However, the results would be subject to the limitations indicated above.

Procedures and techniques of evaluating the effects of flood-prevention measures are in an experimental and formative stage. Methods and procedures of evaluating expected results developed over a period of years to some degree of standardization served as guides in formulating the following procedure for determining observed effects. In turn, findings of this evaluation are expected to provide a basis for improving the planning techniques presently used in estimating effects of watershed-protection projects.

Hydrologic and Sedimentation Measurement

Devices installed for measuring precipitation, runoff, and sediment include the following:

6 standard precipitation gages
2 recording precipitation gages
4 recording precipitation gages, tipping bucket type; of which 3 are installed at sites of pond-stage recording gages and 1 at stream-discharge recording gage
3 pond-stage recording gages at structures 4, 15, and 17
4 reservoir-crest gages at structures 1, 2, 11, and 12
3 stream-discharge recording gages
4 stream-discharge crest gages
2 sediment-sampling stations; 1 at Waterford on Plum Creek and 1 at structure 4

The overall objective of the installed measuring devices is to measure precipitation and resulting streamflow in such a way that hydrographs can be computed and relationships established between runoff, stream stage, and area inundated. Instrumentation will also provide a record of sediment carried by the streamflow. These records of hydrologic and sediment data will provide a basis for computing the effects of installed measures on stream discharge, stage, and area inundated during storms occurring within the evaluation period. In turn, these physical effects of installed measures, coupled with results of economic studies, will provide a means for computing flood-prevention benefits. Records obtained from this intensive network of measuring devices will be particularly useful in improving present knowledge of rainfall-runoff-discharge rate relationships under varying storm situations. These data are essential in formulating and evaluating watershed-protection projects.

Arrangements have been made with the U. S. Geological Survey for cooperative maintenance and operation of the gages indicated above. Plans and arrangements for processing and analyzing the data are being developed. Since the watershed project began, only one flood-producing storm has occurred (April 4, 1957). This storm and all others of similar magnitude occurring during the evaluation period will be analyzed as indicated above to determine the effects of installed measures.

To supplement the gaged measurements, 150 stream-valley cross-sections have been made and high-water marks of floods will be observed and recorded.

Periodic sediment surveys are to be made in the reservoir of structures 4, 15, and 17. To date, soundings to determine the original "profile" have been completed on numbers 4 and 15. One measurement of sediment deposit has been completed on structure No. 4.

Economic Inventory of Watershed

Surveys for project evaluation by use of the procedure set forth in this report, were not instituted until January 1956. Installation of project measures, however, was begun during the fiscal year beginning July 1, 1953.

From an evaluation viewpoint, the preproject period may be regarded as flexible. On this basis, the date of applying each improvement measure marks the end of the preproject period at the location of the improvement. For general purposes of evaluation, however, the years preceding and including 1955 will be used as the preproject period.

For purposes of evaluation, records of accomplishments, resource use, and subsequent changes for evaluation purposes will be maintained on a calendar-year base rather than by fiscal years.

An inventory of watershed conditions prior to installation of the recommended improvements will serve as a general benchmark for measuring watershed changes occurring during the period of analysis. Field surveys and analyses of available data from secondary sources were used to map farm ownership and operating unit boundaries of all farms in the watershed. All farm operators were interviewed to obtain a general concept of the agricultural economy in 1955. Information obtained from this survey includes major land uses, farm tenancy, type and size of farm enterprises, crop and livestock production, gross sales, and off-farm work. It is planned to repeat this survey at the end of 5 years.

Annual use, management, and production data beginning with the year 1952 were obtained for all farm fields (totaling 2,321 acres) in the three watersheds above structures 4, 15, and 17. These data were also obtained for all fields in the flood plain of Plum Creek and tributaries upstream to the site of the floodwater-retarding structures. Information obtained largely from secondary sources, which was assembled for each field, includes acreage in soil units, land use capability classes, and conservation practices that contribute to flood prevention. Such hazards as drought, flood, hail, and insect infestations that may have affected yields were listed. For those fields or parts of fields that are situated on flood plains, a record of past flood damage was made. Summary and analysis of the information obtained by the field survey will provide a field-by-field base for (1) recording changes in production attributable to measures applied through the Watershed Protection Program, (2) assigning benefits to individual or groups of interdependent measures, and (3) recording before and after land uses and the rate of change.

In conjunction with this study, a map of each sample subwatershed and the flood plain was prepared on a photographic base with a scale of 8 inches to a mile. Farm and field boundaries, land use, conservation measures applied, land use capabilities, reservoir flow lines, and other data are indicated on these maps.

On flood-plain lands, the inventory was enlarged to include (1) lands damaged by scouring and deposition from the cumulative effect of previous floods, (2) effect of scour and sediment damage on land productivity, (3) such major and minor fixed improvements as roads, bridges, buildings, fences, and ditches. These factors were recorded and indicated on a map of the flood plain to provide a base for determining the effect of future floods on flood-plain uses and values.

Changes in Land Use, Management, and Production in Sample Areas

For each of the fields inventoried, an annual record of use, yield, management practices including conservation, production, and flood damages will be maintained. Damage will be computed for each flood event and the average depth of inundation at points of damage will be noted. This file of annual data, along with such other available factors as weather will be used in computing the effectiveness of installed works of improvement. It will provide a partial basis for income analysis on treated and untreated fields and farms, including appraisal of returns from alternative treatments when appraisal is feasible. In addition to this material, appraisal of flood-plain benefits resulting from the effect of installed improvements on selected flood-producing storms requires measurements of streamflow, flood stage, and inundated areas.

Data such as land use, soil units, land use capabilities, and conservation practices assembled by fields in the sample subwatersheds indicated above will furnish the basis for periodical determination of soil-cover complexes in the watershed. This classification of land is necessary in computing the relationship of land use and management changes to reduced runoff and sedimentation.

Progress in installing recommended measures for the watershed as a whole is recorded annually. These records include the quantity of each kind of measure installed and costs of those improvements installed by contract or force account. For structural measures, the share of costs borne by Federal, non-Federal, public, and private interests are recorded also. In general, costs of land-treatment measures for the watershed as a whole will be computed by projection of cost data obtained on a sample basis.

Record of Flood Damage

If floods occur during the evaluation period, damages will be appraised by reconnaissance methods and by interviews with the operators of affected properties. These losses will be related to the inventoried items of the flood plain and recorded correspondingly. When the annual enumeration of use, management, and production data for flood-plain fields is taken, information regarding flood losses not available immediately following the flood will be obtained.

Damages to individual improvements or crop fields will be related to depth of flooding which in turn may be related to flood stage and discharge. In this way, the hydrologic measurements described above, along with the results of flood-plain studies, will be utilized to determine flood damages that would have resulted if the improvement measures had not been installed.

As a special phase of damage surveys, the severity of flood-plain scour is determined and its location and extent by fields is recorded. The effects of this kind of land damage on crop yields and production costs will be computed on the basis of farmer experience enumerated at the time the annual field surveys referred to above are made. Over a period of time, rates of productivity recovery and changes in production costs will be observed. These data will be of particular value in improving in current watershed planning methods of estimating benefits from reduced scouring.

Land and Water Management in Reservoir Areas

This phase of the watershed evaluation is aimed at determining the on-site effects of the reservoirs created by the floodwater-retarding structures and the beneficial uses of stored water. From interviews with affected farm operators, records have been made of previous land uses, management practices, and production of the reservoir lands. Based on these data, net income before construction will be computed. Future incomes obtained on the lands that may be flooded periodically and from use of the water detained in the sediment pool will be derived from annual accounts of land and water use, management practices, and associated costs. Those values derived from uses of the permanent reservoir pool that are not measurable in monetary terms will be described and appraised so far as possible in physical quantities of goods and services. Records will be kept also of the costs of maintaining the structures and their appurtenances.

Determination of Reduction in Damage From Specific Storms

Analysis and integration of the information supplied by the flood-plain inventory, the annual record of flood damages by storms, and the hydrologic and sedimentation measurements will furnish the bases for estimating flood-prevention benefits. Final calculation of project benefits owing to reduction of damages resulting from frequent floods may be delayed for a year or more following a flood because of the delay in summarizing gage records and the volume of hydrologic and engineering assistance required for the analysis. In the event of a large infrequent flood, however, a special preliminary analysis will be made and a report will follow immediately. The investigation will cover storm characteristics, runoff, peak discharges, damages, and benefits afforded by measures installed. Data collected in other phases of the watershed evaluation, along with reconnaissance-type information, will be used in appraising flood damages.

Special Analysis of Stream-Channel Improvement

A separate analysis will be made of the costs and returns of stream-channel improvement on the main stem of Plum Creek. Information on costs associated with changed uses and differences in crop yields will be obtained from operators of land adjacent to improved stream channels. In turn, these factors will be analyzed to compute increases in net income arising from intensification of land use. Hydrologic measurements will indicate the area of effectiveness of the entire watershed program within the stream valley that borders the improved stream channel for selected flood-producing storms. Thus, total benefits in the affected area may be computed. For this special study, hydrologic effects should also be estimated for assumed conditions of (1) channel improvement made but no floodwater-retarding structures installed, and (2) structures installed but no channel improvement made. These hydrologic determinations, along with the economic records, will provide a basis for computing incremental influences of two of the major flood-prevention features of the watershed project.

Costs of Land-Treatment Measures

Additional study has been started to obtain from farm operators detailed information regarding expenditures required to install, maintain, and operate land-treatment measures and critical-area vegetation established under the watershed program. A special work sheet was developed to furnish a record of cost items encumbered for separate practices. This form lists the kinds, quantities and costs of material, the kinds and numbers of hours of machinery and equipment used, labor used, and other related data. Information regarding depreciation and other fixed costs of machinery and equipment was obtained from secondary sources. Based on these data, the total cost of installing and maintaining improvement measures will be computed.

This survey covers all the farms in the three sample subwatersheds, but for some measures, data will be enumerated from farmers elsewhere in the watershed. Cost data obtained through this sample will be sufficiently representative to provide a base for estimating costs of conservation measures throughout the entire watershed.

PROGRESS OF EVALUATION

The rest of this progress report on evaluation of the watershed program sets forth the accomplishments and findings with respect to carrying out the several phases of the plan of evaluation heretofore described.

Progress in carrying out the several segments of the evaluation plan is recorded under general subject matter headings rather than under the segments themselves. This was done to avoid duplication and to minimize fragmentation of material.

Land Use and Management

The land in the watershed is predominantly agricultural; less than 2 percent is used for nonagricultural purposes. Public roads and waterways occupy 90 percent of the 440 acres of land not in farms; the village and rights-of-way take up the rest.

In 1955, the watershed farmland was held by 129 owners and operated within 136 units. Most of the farms were owner-operated; only 24 percent were operated by tenants or farm managers. Residences of owners of the tenant-operated farms were in or near the watershed.

Organization and other characteristics of the watershed farms in 1955, as determined by a survey of all farms that have 50 percent or more of their lands in the watershed, are indicated in table 7. This survey covered 140 farms averaging 168 acres in size. Dairy-crop, other livestock-crop, and crop-livestock farms predominated. Crops and pasture comprised 32 percent and 63 percent, respectively, of the farmland. Tobacco, grown on 99 percent of the farms, occupied only 1.4 percent of the farmland area, yet tobacco sales constituted 29.9 percent of all farm sales.

Value of sales on more than 50 percent of the farms exceeded $6,000 in 1955 (table 8). Sales were less than $2,000 on only 18.6 percent of the farms. Income from off-farm employment was substantial on 25 farms whose operators worked off farm an average of 168 days in 1955. Those farmers whose sales exceeded $6,000 operated about 76 percent of all cropland and improved pastureland in the watershed and 54 percent of the unimproved pastureland.

Major uses of farmland in 1955, as determined by a survey of all farms in the watershed, are shown in table 9. Greater intensity of use is indicated in the flood plain, where 76 percent of the farmland was used for crops and 15 percent for pasture. On the uplands, 29 percent of the farmland was used for crops and 65 percent for pasture. In the sample study areas, for which detailed land use was recorded, these differences in intensity of cultivation are borne out also (table 10). In the flood plain, about 53 percent of all land was planted to corn or tobacco; on the uplands, the corresponding proportion was about 12 percent. In contrast to the difference in crop distribution, there was relatively more idle land in the flood plain than on the uplands.

In general, the major use of farmland in the watershed is within the capability of the land with respect to conservation requirements. Greater deviation is evident for cropland than for the other major uses. As indicated in table 11, about 11 percent of the crops in the upland study areas in 1955 were raised on capability class VI lands. To assure adequate erosion control, the watershed plan recommends that these lands be used for permanent pasture or woods.

Table 7. - Economic characteristics of farms, by type of farm, Plum Creek Watershed, Ky., 1955 1/

Item	Unit	Type of farm 2/				All farms
		Dairy-crop	Livestock-crop	Crop-livestock	Other	
Tenure of operator:						
Owner-operated	Number	45	21	29	10	105
Tenant-operated	do.	26	3	3	1	33
Part owner	do.	---	2	---	---	2
Total	do.	71	26	32	11	140
Average size of farm	Acre	190	201	131	63	168
Land use per farm						
All crops	do.	65	63	32	13	53
Tobacco	do.	2.6	2.4	2.1	.9	2.3
Improved pasture	do.	76	77	34	22	62
Unimproved pasture 3/	do.	40	52	55	23	44
Miscellaneous	do	9	9	10	5	9
Livestock per farm:						
Cows milked	Number	22	7	7	1	14
Beef cattle	do.	1	13	3	1	3
Ewes	do.	1	18	11	---	7
Sows	do.	2	5	1	1	2
Value of sales per farm:						
Dairy and dairy products	Dollar	6,310	1,600	760	50	3,670
Beef	do.	40	1,130	80	20	250
Sheep	do.	20	350	170	---	110
Hogs	do.	510	1,590	130	50	590
Poultry	do.	30	160	20	---	50
Tobacco	do.	2,340	2,130	1,760	790	2,050
Other crops	do.	60	320	190	30	140
Total	do.	9,310	7,280	3,110	940	6,860
Off-farm work:						
Farmers reporting	Number	11	3	7	4	25
Days per farm reported	do.	139	167	198	72	168

1/ From survey of all farms that have 50 percent or more of their area in the watershed.

2/ "Dairy-crop" farms include those on which more than 50 percent of gross sales are derived from dairy or dairy products and 10 percent or more of total sales are obtained from crops. "Livestock-crop" farms include those on which more than 50 percent of gross sales are obtained from all livestock and livestock products and 10 percent or more are derived from crops. "Crop-livestock" farms include those on which more than 50 percent of total sales are from crops and 10 percent or more are obtained from livestock and livestock products. "Other" farms include those that carry on only minor enterprises, which are usually part-time and noncommercial.

3/ Woodland is included with unimproved pasture.

Table 8. - Relation of use of land in farms to volume of gross sales, Plum Creek Watershed, Ky., 1955 1/

Gross sales	Percentage of all farms	Percentage of all gross sales	Percentage of all farmland in selected uses			
			All farmland	Cropland	Improved pasture	Unimproved pasture
	Percent	Percent	Percent	Percent	Percent	Percent
Under $2,001	18.6	3.5	7.6	4.8	5.8	12.6
$2,001-$4,000	20.0	8.4	15.0	11.6	12.2	22.3
$4,001-$6,000	10.0	7.3	7.8	7.8	5.9	10.9
$6,001-$8,000	17.1	17.5	20.9	17.5	19.0	27.0
$8,001-$12,000	18.6	27.3	21.6	22.6	26.2	15.9
$12,001 and over	15.7	36.0	27.1	35.7	30.9	11.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

1/ From survey of all farms that have 50 percent or more of their lands in the watershed.

Table 9. - Major uses of farmland, Plum Creek Watershed, Ky., 1955 1/

Land use	Upland	Flood plain 2/	Total watershed
	Acres	Acres	Acres
Cropland	6,562	741	7,303
Tobacco 3/	260	61	321
Improved pasture	8,438	145	8,583
Unimproved pasture 4/	6,140	0	6,140
Other land	1,133	88	1,221
All farmland	22,273	974	23,247

1/ From a survey of sample subwatersheds and flood plain.

2/ Flood-plain area excludes a small acreage of land along secondary and tertiary tributaries of Plum Creek.

3/ Acreage of tobacco is included in cropland acreage.

4/ Includes woodland pasture.

Table 10. - Farmland use in upland study areas and flood plain, Plum Creek Watershed, Ky., 1955 1/

Farmland use	Upland study areas		Flood plain	
	Acres	Percent	Acres	Percent
Tobacco	34.3	1.5	60.8	6.2
Corn	253.8	10.9	456.6	46.9
Small grain	46.5	2.0	11.4	1.2
Hay	540.7	23.3	202.2	20.8
Other crops	28.1	1.2	9.7	1.0
Idle cropland	9.6	.4	46.5	4.8
Rotation pasture	170.4	7.3	30.5	3.1
Total cropland	1,083.4	46.6	817.7	84.0
Permanent pasture	943.9	40.7	114.4	11.7
Woods	260.5	11.2	40.7	4.2
Other	34.0	1.5	1.0	.1
Total noncropland	1,238.4	53.4	156.1	16.0
Grand total	2,321.8	100.0	973.8	100.0

1/ From surveys of sample subwatersheds and flood plain.

Table 11. - Percentage of land use in land use capability classes, Plum Creek Watershed, Ky., 1955 1/

Land use capability class	Upland study area				Flood plain			
	Cropland	Permanent pasture	Woods	Idle	Cropland	Permanent pasture	Woods	Idle
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
I, II & III	71	31	2	38	100	100	69	100
IV	18	17	1	26	---	---	31	---
VI	11	47	59	26	---	---	---	---
VII	---	5	38	10	---	---	---	---
Total	100	100	100	100	100	100	100	100

1/ From surveys of land use in sample subwatersheds and flood plain and soil conservation surveys.

Land uses in the upland study areas and on the flood plain from 1952 to 1956 inclusive are indicated in table 12. Factors known to have influenced changes in specific land uses include low summer rainfall in 1952, 1953, and 1954, heavy rainfall in 1955, tobacco acreage allotments, and the soil bank. Most of these factors are not readily subject to control, and their effects must be recognized in evaluating the effects of installed works of improvement. Methods of economic analysis other than those based on historical comparison of output from fields with and without conservation treatments will be used also.

Crop Yields

Average yields of major crops in the upland study areas and the flood plain are shown in table 13. Average yields of most of the crops in 1956 were higher than in 1955 and also higher than those from 1952 to 1956. Larger yields in 1956 were due mainly to a favorable distribution of rainfall during the growing season. Except for a few isolated instances, effects of conservation practices installed in 1952-56 on crop yields have not yet been appraised. Analyses to estimate these effects will take into account other determined yield-influencing factors.

Except for tobacco, average yields for 1952-56 in subwatershed 4 are higher than those in the other two upland areas. These differences are also reflected in yearly yields. More productive soils and gentler slopes in subwatershed 4 contribute to higher crop yields (table 14).

Average yields of corn grown on the flood plain from 1952 to 1956 are substantially above those produced on upland farms; however, minor variations are indicated for individual years.

Analysis was made of crop yields for 1952-56 to determine their relationship to land use capability. Significant correlation was observed only for pasture and hay. The influences of different production and management practices and soils on yields overshadowed the effect of land use capability.

Water Utilization

Long-term precipitation records at the Weather Bureau Station at Taylorsville, near the mouth of Plum Creek, indicate that water-management measures are needed for both flood and erosion prevention and for better utilization of water. Annual precipitation averaged slightly above 46 inches from 1920 to 1956, but it ranged from 28 inches in 1934 to a high of 63.8 inches in 1942. The long-term monthly record of precipitation indicates even wider variations.

Table 12. - Land use in upland study areas and flood plain, Plum Creek Watershed, Ky., 1952-56 1/

Land use	1956	1955	1954	1953	1952
	Acres	Acres	Acres	Acres	Acres
SAMPLE DRAINAGE AREA 4					
Tobacco	18.0	17.2	20.7	20.5	18.5
Corn	147.8	134.5	134.0	127.7	106.7
Small grain	75.5	43.5	66.5	31.5	21.5
Hay	243.5	310.2	273.5	282.5	259.5
Other crop	10.5	5.8	3.8	.8	.8
Idle cropland	47.3	3.3	---	3.5	38.0
Rotation pasture	54.5	106.3	122.3	154.3	187.8
Total cropland	597.1	620.8	620.8	620.8	632.8
Permanent pasture	442.9	419.2	419.2	419.2	407.2
Woods	0	0	0	0	0
Other	13.5	13.5	13.5	13.5	13.5
Total noncropland	456.4	432.7	432.7	432.7	420.7
Total land	1,053.5	1,053.5	1,053.5	1,053.5	1,053.5
SAMPLE DRAINAGE AREA 15					
Tobacco	9.2	11.1	9.7	17.9	15.6
Corn	57.5	86.7	112.5	84.0	40.5
Small grain	18.5	---	22.0	26.5	---
Hay	197.1	191.5	188.0	165.2	222.2
Other crop	8.0	21.3	3.5	---	---
Idle cropland	8.2	4.6	2.0	3.0	2.5
Rotation pasture	75.1	60.0	24.5	79.1	97.9
Total cropland	373.6	375.2	362.2	375.7	378.7
Permanent pasture	256.4	256.7	269.7	254.2	251.2
Woods	83.2	89.5	89.5	91.5	91.5
Other	28.7	20.5	20.5	20.5	20.5
Total noncropland	368.3	366.7	379.7	366.2	363.8
Total land	741.9	741.9	741.9	741.9	741.9

-Continued

Table 12. - Land use in upland study areas and flood plain, Plum Creek Watershed, Ky., 1952-56 1/--Continued

SAMPLE DRAINAGE AREA 17

Land use	1956	1955	1954	1953	1952
	Acres	Acres	Acres	Acres	Acres
Tobacco	4.3	6.0	7.3	7.2	8.9
Corn	24.0	32.6	18.3	---	3.3
Small grain	---	3.0	---	---	---
Hay	28.1	39.0	57.0	74.2	57.2
Other crop	11.0	1.0	1.2	---	---
Idle cropland	3.7	1.7	1.7	1.7	---
Rotation pasture	0	4.1	17.9	20.3	34.0
Total cropland	71.1	87.4	103.4	103.4	103.4
Permanent pasture	282.0	268.0	248.0	248.0	248.0
Woods	169.7	171.0	175.0	175.0	175.0
Other	3.6	---	---	---	---
Total noncropland	455.3	439.0	423.0	423.0	423.0
Total land	526.4	526.4	526.4	526.4	526.4

FLOOD PLAIN 2/

Tobacco	51.3	60.8	65.3	66.3	---
Corn	413.5	456.6	382.1	371.0	---
Small grain	51.0	11.4	44.1	14.8	---
Hay	169.3	202.2	221.3	234.7	---
Other crop	12.8	9.7	3.3	33.8	---
Idle cropland	71.0	46.5	48.2	35.3	---
Rotation pasture	53.7	30.5	52.4	53.4	---
Total cropland	822.6	817.7	816.7	809.3	---
Permanent pasture	114.4	114.4	114.4	114.4	---
Woods	35.8	40.7	42.2	49.6	---
Other	1.0	1.0	.5	.5	---
Total noncropland	151.2	156.1	157.1	164.5	---
Total land	973.8	973.8	973.8	973.8	---

1/ From survey of sample subwatersheds and flood plains.
2/ Historical data incomplete for 1952.

Table 13. - Average crop yields in flood plain and upland study areas, Plum Creek Watershed, Ky., 1952-56 1/

Crop and year	Flood plain	Subwatersheds		
		4	15	17
	Pounds	Pounds	Pounds	Pounds
Tobacco:				
1952	1,618	1,835	1,785	1,768
1953	1,548	2,076	1,807	2,116
1954	1,721	1,922	2,087	2,109
1955	1,537	1,723	1,552	2,180
1956	1,800	1,836	1,959	2,154
Average	1,640	1,886	1,838	2,072
	Bushels	Bushels	Bushels	Bushels
Corn grain:				
1952	69	44	39	---
1953	71	65	49	---
1954	75	37	36	47
1955	73	67	45	62
1956	75	87	57	44
Average	73	62	44	52
	Tons	Tons	Tons	Tons
Corn silage:				
1952	17.0	2.5	2.5	---
1953	17.0	10.7	6.5	---
1954	16.0	5.0	6.6	---
1955	11.0	12.2	10.0	---
1956	11.7	10.8	14.5	---
Average	12.1	10.5	8.9	---
All hay:				
1952	1.5	1.5	.5	0.5
1953	1.7	1.3	.7	.5
1954	1.6	1.7	.8	.5
1955	2.1	2.5	1.1	1.0
1956	2.1	3.2	2.0	1.6
Average	1.9	2.1	.9	.7
	Animal units	Animal units	Animal units	Animal units
All pasture: 2/				
1952	54	51	37	30
1953	51	50	38	30
1954	57	54	59	30
1955	57	90	77	42
1956	95	100	62	61
Average	62	62	50	39

1/ From annual surveys of sample subwatersheds and flood plain.
2/ Animal unit days of grazing per acre.

Table 14. - Acreages of soil units in sample upland areas and flood plain, Plum Creek Watershed, Ky.

Soil units	Subwatersheds						Flood plain	
	4		15		17			
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
2M5 - 2M5F3 1/	2.4	0.2	20.0	2.7	6.1	1.1	783.4	80.4
2M4S - 2M32 - 2M42 - 2M4L 2/	492.2	46.7	252.1	34.3	119.5	22.9	101.4	10.4
2F43 - 2F32 - 2F4L 3/	504.2	47.9	294.6	40.1	---	---	18.6	1.9
2M4d3 - 2M4d4 4/	49.0	4.7	---	---	---	---	26.9	2.8
3M32 5/	---	---	12.5	1.7	---	---	---	---
3M42 6/	---	---	.4	.1	---	---	40.6	4.2
4H2 - 4eF3 - 5eHL 7/	5.7	.5	154.8	21.1	397.2	76.0	2.9	.3
Total 8/	1,053.5	100.0	734.4	100.0	522.8	100.0	973.8	100.0

1/ Deep, well-drained, medium-textured soils (alluvial) (Huntington).

2/ Deep, well-drained, medium-textured soils (Nicholson-Lowell-Shelbyville).

3/ Deep, well-drained, medium heavy-textured soils (Beasly-Bedford).

4/ Deep, imperfectly drained, medium-texture soils (alluvial) (Newark-Melvin).

5/ Moderately deep, well-drained, medium-textured soils (Beasly).

6/ Moderately deep, moderately drained, medium-textured pan soils (Bedford-Captina).

7/ Shallow, well-drained, moderately heavy to heavy-textured soils (Fairmont-Maddox).

8/ Excludes 7.5 acres and 3.6 acres of land in structures and sediment pools in subwatersheds 15 and 17, respectively.

Compiled from SCS watershed project records with assistance of SCS soil scientists.

Water requirements for optimum production are seldom satisfied. To date, however, these deficiencies have not been met by irrigation. Water stored in farm ponds has been used primarily for livestock and recreation. At the start of the watershed program (July 1, 1953), 129 farm ponds had been constructed; 88 additional ponds were completed by July 1957.

During the 4 years preceding July 1957, water-storage facilities in Plum Creek Watershed increased from about 130 acre-feet to 580 acre-feet. About 80 percent of the increased storage is provided by the sediment pools of floodwater-retarding structures and the rest by farm ponds.

Wells and cisterns provide the major supply of water for farm and village domestic requirements.

The nine floodwater-retarding structures presently installed provide 1,938 acre-feet of total storage. Of this amount, 362 acre-feet are required to store the sediment expected to accumulate during a 50-year period. The aggregate surface area of the reservoirs when full is about 215 acres. The surface area of the sediment pools totals 81 acres, leaving 134 acres in the detention pools. Land in the sediment pool areas is permanently flooded, while in the detention pool areas, flooding will be intermittent.

The Kentucky Department of Conservation, Division of Fish and Game, stocked all temporary ponds with fish. Three of the ponds were fished in 1957 and the remaining six are expected to come into production in 1958. From April 1957 to October 1957, approximately 250 fishing visits were made in the pool above floodwater-retarding structure 12. About 500 pounds of fish were taken from this one pool. Other types of recreation--swimming, for instance, were furnished also, although no quantitative measurement of this sport has been made.

Consumptive use of the water stored in sediment pools is available to the 21 farmers on whose land the pools are located. All of these farmers have livestock, and thus far the predominant consumptive use of this water has been for livestock. The new water supplies for livestock furnish convenient supplements to those utilized before the dams were constructed. Although irrigation is not practiced in the watershed, two farmers have said they intended to use water from this source to irrigate tobacco.

The average annual value of crop and pasture production obtained from the permanently flooded lands before the reservoirs were constructed was $3,944. As indicated in table 15, nearly two-thirds of the value of the production foregone was represented by tobacco. The farmer involved made up a large part of this loss by growing his allotted acreage of tobacco on another part of his farm. By this shift in land use, the production loss was transferred to a less intensive crop. Similar shifts in farmland use may be in process to compensate for decreased production of corn. Changes of this kind will be recorded in future surveys.

In the detention pool areas, the average annual value of production before construction was $1,993. During the short time since construction, no change in production has been observed in these areas.

Table 15. - Average land use and value of production obtained in sites of 9 floodwater-retarding structures before construction, Plum Creek Watershed, Ky. 1/

Land use	Sediment pool 2/		Detention pool 3/		Total	
	Area	Value of production	Area	Value of production	Area	Value of production
	Acres	Dollars	Acres	Dollars	Acres	Dollars
Tobacco	2.9	2,538	---	---	2.9	2,538
Corn	10.6	910	1.8	186	12.4	1,096
All hay	9.7	305	43.0	1,446	52.7	1,751
Pasture	21.4	191	57.7	361	79.1	552
Idle	31.4	---	31.4	---	62.8	---
Water	5.3	---	---	---	5.3	---
Total	81.3	3,944	133.9	1,993	215.2	5,937

1/ From surveys of all land in reservoirs of floodwater-retarding structures.
2/ Includes area and production of land in the dam site.
3/ Includes area and former production of land in the spillway.

Costs of Works of Improvement

Sources of information for computing costs of works of improvement include project records of technical service and disbursements, along with data obtained by interviews with farmers. Costs of constructing floodwater-retarding structures, revegetating critical areas, and improving subwatershed waterways were computed for the total quantities of the measures established from the start of the program through 1956. Costs of all other measures were obtained on a sample basis. No costs for maintaining installed measures have yet been recorded.

Revegetation of critically eroding areas was accomplished by contract. Costs of installing this measure in 1955 and 1956 are shown in table 16. Contracts for the work required working the land to a 3-inch depth and seeding Kentucky 31 fescue at a rate of 20 pounds per acre. In 1956, 600 pounds of 5-10-10 fertilizer and 2 tons of limestone per acre were also required. Landowners furnished the grass seed and paid for land clearing when clearing was necessary. On 64 percent of the area seeded in 1955, supplemental seeding was made in 1956 to establish better cover for grazing. This practice is expected to be followed in 1957 on much of the land seeded in 1956. Including the cost of supplemental seeding, the total cost per acre improved averaged $64 in 1955 and $68 in 1956, which compares favorably with the estimated planning cost.

Table 16. - Cost of revegetating critical areas, Plum Creek Watershed, Ky., 1955 and 1956 1/

Requirements	1955 - 55 acres established			1956 - 228 acres established		
	Quantity	Cost		Quantity	Cost	
		Federal	Private		Federal	Private
		Dollars	Dollars		Dollars	Dollars
Land clearing	21.5 acres	---	598	70.5 acres	---	2,840
Grass seed	1,100 pounds	---	246	5,560 pounds	---	1,141
Preparation and planting 2/	55 acres	2,196	---	228 acres	10,722	---
Supplemental seed 3/	375 pounds	---	125	140 pounds	---	50
Supplemental planting	35 acres	---	19	11 acres	---	6
Engineering service 4/	---	349	---	228 acres	833	---
Total cost	---	2,545	988	---	11,555	4,037
Average cost per acre	---	46.27	17.96	---	50.67	17.71

1/ These data were developed for establishment of the measure on 10 farms in 1955 and 27 farms in 1956.

2/ Bogging, fertilizing, and planting under contract. Includes 600 pounds 5-10-10 fertilizer per acre and 2 tons limestone per acre in 1956 only.

3/ Consists of grass and legume seed sown during winter or spring to supplement initial seeding of Kentucky 31 fescue.

4/ Engineering services include Federal cost of planning and supervising.

Costs of improving 5.1 miles of subwatershed waterways shown in table 17 averaged $24.47 per 100 feet constructed. Construction of the waterways was accomplished under contract. The average cost of these improvements per 100 linear feet of channel was approximately three times greater than the work plan estimate. However, these average installation costs represent records of only 5.4 percent of the subwatershed waterways to be constructed.

Costs of cover cropping and pasture seeding are shown in tables 18 and 19, respectively. These costs were computed for the quantities of the measures installed in 1956 in the upland and flood-plain study areas. The cost of cover cropping in 1956, which averaged $8.02 per acre was about $1.65 higher than the average estimated in the work plans. Pasture seeded in 1956 for which records were obtained cost an average of $8.45 per acre, or only 17 percent of the cost as estimated in the work plan. This large difference in cost is due partly to the application of no lime or fertilizer and partly to

Table 17. - Cost of subwatershed-waterway improvement, Plum Creek Watershed, Ky., 1956 1/

Item	Quantity	Cost		
		Federal	Private	Total
		Dollars	Dollars	Dollars
Requirements for 5.1 miles of waterways:				
Land clearing	8 acres	---	171	171
Grass seed	675 pounds	---	178	178
Construction	5.1 miles	4,500	---	4,500
Seeding	30.7 acres	---	63	63
Grass seed for repair 2/	120 pounds	---	53	53
Repair seeding 2/	7.5 acres	---	68	68
Engineering services 3/	---	1,556	---	1,556
Total cost	---	6,056	533	6,589
Average cost per 100 feet	---	22.49	1.98	24.47

1/ These data were developed for establishment of the measure on 12 farms.
2/ Seeding required to repair washout areas.
3/ Engineering services include Federal cost of planning and supervising.

Table 18. - Cost of cover cropping, Plum Creek Watershed, Ky., 1956 1/

Item	Unit	Quantity	Total cost	Cost per acre
			Dollars	Dollars
Requirements for 568 acres of cover cropping:				
Seed:				
Wheat	Bushel	414	984	1.73
Barley	do.	159	278	.49
Rye	do.	567	1,175	2.06
Vetch	Pound	150	21	.04
Oats	Bushel	14	15	.03
Total	---	---	2,473	4.35
Machinery:				
Tractor	Hour	806	1,078	1.90
Disk	do.	590	193	.34
Drill	do.	202	91	.16
Total	---	---	1,362	2.40
Labor	do.	964	723	1.27
Grand total	---	---	4,558	8.02

1/ Data were developed for establishment of measure on 55 farms in the upland study areas and the flood plain.

Table 19. - Cost of pasture seeding, Plum Creek Watershed, Ky., 1956 1/

Item	Unit	Quantity	Total cost	Cost per acre
			Dollars	Dollars
Requirements for seeding 76 acres:				
Seed:				
Orchard grass	Pound	572	132	1.74
Lespedeza	do.	1,340	168	2.21
Red clover	do.	480	197	2.59
Timothy	do.	160	38	.50
Kentucky 31 fescue	do.	20	2	.03
Total		2,572	537	7.07
Machinery:				
Tractor	Hour	28	42	.55
Disk	do.	22	9	.12
Drill	do.	6	4	.05
Total	do.	56	55	.72
Labor	do.	66	50	.66
Grand total		---	642	8.45

1/ These data were developed for establishment of the measure on 6 farms. The practice of pasture seeding reported here includes only those situations in which it is included in the crop rotation.

the fact that the seeding was a phase in the crop rotation. Costs of pasture seeding recommended in the work plan were based on conversion of cropland to permanent pasture and included costs of heavy applications of lime and fertilizer.

Although pasture mowing was not specifically included among the recommended practices listed in the work plan, it is commonly practiced in the watershed. An average cost of $1.63 per acre for this measure is shown in table 20.

Costs of land-treatment measures applied will continue to be compiled and recorded on a sample basis. When the evaluation study is completed, data will be available from which to project cost information to the total watershed program.

Table 20. - Cost of pasture mowing, Plum Creek Watershed, Ky., 1956 1/

Item	Unit	Quantity	Total cost	Cost per acre
			Dollars	Dollars
Costs for 873 acres of pasture mowing:				
Machinery:				
Tractor	Hour	568	757	0.87
Mower	do.	568	239	.27
Labor	do.	568	425	.49
Total	---	---	1,421	1.63

1/ These data were developed for establishment of the measure on 26 farms in the upland study areas and the flood plain.

Upland Management as Affected by Works of Improvement

In the three upland study areas, land use and management data, previously discussed, was recorded for 251 fields containing a total of 2,321 acres. In 1955, 141 of these fields were used for crops or rotation pasture and 78 for permanent pasture; 20 fields were in woods, and 12 were idle.

Changes in land use and additional land-treatment measures are needed on some of these fields to fulfill watershed-protection and flood-prevention requirements. On 44 fields or parts of fields containing 126 acres, present land use should be changed either to pasture or to woods. But, if desired by the farmers, 280 acres presently idle, wooded, or pastured could be converted to more intensive uses if adequate conservation practices were followed.

Changes in land use in the upland study areas from 1953 to 1956 included both favorable and unfavorable changes so far as the recommended program is concerned. During this period, 39 acres of steep and eroded land (land use capability class VI) were converted from cropland to pasture. However, on 29 acres of land of this type, use was changed from permanent pasture to crops. The net change of 10 acres is approximately equal to an 8-percent reduction in acreage of crops on capability class VI lands. Other recommended land use changes to crops in the upland study areas during 1953-56, included conversion of 58 acres of pasture and idle lands in capability classes I, II, and III.

Based on SCS records, land treatment measures presently installed or practiced on the sample upland fields and additional needs are as follows:

Measure	Installed	Additional needs
Revegetation of critical areas---acres----	53.3	1.5
Contour farming----------do.-----	169	329
Cover cropping----------do.-----	220	296
Pasture seeding----------do.-----	405	538
Diversions----------feet-----	1,600	16,100
Waterways----------acres----	.4	13.3
Ponds----------number---	6	6
Woodland fencing----------acres----	0	0

Conservation farm plans have been made for all sample fields under study. These plans, along with the record of field use and management for 1952-56, made it possible to classify the fields by the degree of conservation attained. This classification indicates in general terms that 61 percent of all the fields are used and managed in such a way that they will meet minimum or greater conservation requirements. On the remaining fields, changes in use or additional conservation practices are needed to provide necessary conservation.

Analysis of the use and management of the crop and rotation pasture fields to determine the level of conservation presently attained indicates that 64 percent of all fields in these uses meet minimum requirements. Findings of this analysis are shown in table 21.

Evaluation of returns related to level of conservation attainment has not been attempted. Appraisals of this kind and of costs of inputs over a longer period are contemplated. Determination of value of production related to individual conservation practices or groups of practices is planned also. Together with historic comparisons, these analyses will be used eventually to estimate on-site benefits from watershed improvements.

Table 21. - Classification of crop and rotation pasture fields in upland study areas according to level of conservation attained, Plum Creek Watershed, Ky., 1/

Sample watersheds	At or above minimum requirements		Below minimum requirements	
	Number fields	Acres	Number fields	Acres
4	74	748	40	305
15	42	407	32	335
17	34	467	11	59
Total	150	1,622	83	699

1/ Classification is based on technical guides to conservation requirements developed by the Soil Conservation Service in Kentucky.

Critically eroding areas seeded to grass in 1955 provided substantial grazing in 1956. Grazing use and estimated value of production for each tract of land revegetated are shown in table 22. Production on the total acreage increased nearly sixfold and the average return per acre increased by $10.00.

Table 22. - Production and value of grazing of revegetated critical areas, Plum Creek Watershed, Ky.

Land use	Acreage in tract	Before establishment - 1955		After establishment - 1956	
		Total production	Value of production	Total production	Value of production
	Acres	A.U.M. 1/	Dollars	A.U.M. 1/	Dollars
Pasture	2.8	2.6	8	14.6	47
Pasture	8.5	3.7	12	5.1	16
Waste	4.2	---	--	14.7	47
Pasture	4.6	6.8	22	22.1	70
Pasture	3.2	3.3	11	7.4	24
Pasture	12.0	5.0	16	50.4	161
Waste	4.0	---	--	8.1	26
Pasture	3.4	5.2	17	6.9	22
Pasture	4.2	4.2	13	8.4	27
Waste	8.2	---	--	65.6	209
Total	55.1	30.8	99	203.3	649

1/ Animal unit months of grazing.

Effects of changes in land use and production on farm organization and income will be studied through two general approaches. The first of these will be records of farm organization and other economic characteristics of all farms in the watershed in 1955. At the end of the evaluation period, the second approach will be to compute the effect of changes in land use and production on typical farms by budgeting methods.

Use of Flood Plain and Flood Damages

About 10 percent of the flood-plain land shows evidence of scour damage from flooding on the main stem of Plum Creek. Field surveys indicate the location of small areas of such damage in 50 fields. Additional scour and deposition in the main stem flood plain are caused by runoff from adjacent hillsides. However, no measurement of the area affected by this source of runoff has been made. In the areas damaged by Plum Creek floods, the quantity of soil removed varies from 5 to 60 percent. The effect of soil loss on yield or cost of production has not yet been determined. Continuing surveys will obtain information in this regard.

A greater than proportionate share of the most intensive crops in the watershed are grown on the flood plain. Although flood-plain lands represent 4.2 percent of the total watershed area, approximately 19 percent of the tobacco and 17 percent of the corn are grown on these lands. The value of production from these two crops represents about 90 percent of the value of all crop and pasture production obtained in the flood plain. Tobacco and corn are particularly vulnerable to damage from inundation when floods occur during the growing season.

In 1955, 46 acres of land subject to flooding were idle, 41 acres were wooded, and 114 acres were permanent pasture. Evaluation studies made to date do not reveal the extent to which these relatively low intensities of land use are influenced by flood hazards. Changes in future uses of these lands will be recorded and analyzed to determine their relationships with flood protection provided by works of improvement.

An inventory of property subject to damage from flooding includes such improvements as fences, roads, bridges, residences, and other farm buildings. The extent of these improvements, along with the value of production of flood-plain crops, is shown in table 23.

Table 23. - Property in flood plain partially or completely protected by works of improvement, Plum Creek Watershed, Ky., 1955

Item	Unit	Quantity	Value of production
			Dollars
Crops and rotation pasture	Acres	818	---
Barbed wire fence	Rods	2,155	---
Woven wire fence	do.	4,119	---
Houses	Number	15	---
Store building	do.	1	---
Barns	do.	5	---
Highway bridges	do.	6	---
Roads	Feet	14,520	---
Crop production:			
Tobacco	Acres	61	52,149
Corn	do.	456	42,144
Small grain	do.	12	263
All hay	do.	202	9,563
Pasture	do.	145	1,182
Total	---	---	105,301

The flood of April 4, 1957, is the only one that has occurred in the Plum Creek Watershed since inception of the project. About 200 acres, or 20 percent of the flood plain, were inundated. No land was inundated on the flood plains of those tributaries on which floodwater-retarding structures were located. Approximately 15 acres of land were damaged by scour. Of this land, 13.7 acres had not been damaged by previous floods. In some small locations, gullies up to 30-inch depths were noted. No repair costs or loss in productivity were reported immediately following the flood when the survey of damage was made. Such losses will be ascertained in carrying out annual surveys indicated earlier in this report.

Other damages totaled $1,373, including a $958 damage to fixed improvements and a $415 damage to crops. These losses were appraised separately for each site affected, and the depth of water was recorded. The kind and amount of damage sustained are shown below:

Damage from floodwater, April 4, 1957 flood, Plum Creek Watershed, Ky.

Kind and extent of damage	Damage
	Dollars
Fences--253 rods	593
Graded streambank--50 feet	25
Concrete levees--75 feet	300
2 earth levees--50 feet	40
8 tobacco beds--6,700 square feet	355
Alfalfa--1 acre	50
New seeding of clover--1.5 acres	10
Total	1,373

How much greater the damages of the April 1957 flood would have been if works of improvement had not been installed has not been determined. Analyses of the effects of the installed improvements on peak discharge and flood stage will be made by procedures described elsewhere in this report before evaluation of the project is completed. Relationships between flood stage and area inundated will permit estimation of the area that would have been flooded had the improvements not been installed. Thus damages without existing improvements may be appraised. The project benefits will be equal to the difference between these damages and those that actually occurred.